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NOTES ON THE THERAPEUTICS OF RADIUM IN THE BATH WATERS

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NOTES ON THE THERAPEUTICS OF RADIUM IN THE BATH WATERS.

A Handbook for the Medical Profession, published by the Bath Corporation with the approval of the Bath Medical Committee of the British Medical Association.

COMPILED BY JOHN HATTON,
DIRECTOR OF THE BATHS.

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FOREWORD

This Handbook has been compiled in order to place before the Medical Profession the results of the recent investigations of the Hot Springs of Bath, conducted by Professor Sir William Ramsay, K.C.B., F.R.S., to whom the City of Bath will be ever indebted for his exhaustive examination of the Waters and for the report which is given in this booklet.

The Bath Branch of the British Medical Association formed a special committee to consider the clinical aspect of the subject and this committee kindly contributed the important article on "Radio-Activity as a factor in the efficacy of the Bath Mineral Waters."

A few extracts from leading Medical Journals dealing both with Radium in the Bath Waters and Radium-therapy generally and other press comments are also included, and a short description is given of the principal methods in use at the Hot Mineral Baths for the therapeutic application of the Radio-Active Waters and Gases.

Report on the Mineral Waters of Bath.

By Professor Sir William Ramsay, K.C.B., F.R.S.

Some years after my discovery of helium in 1895, Lord Rayleigh made an estimate of the amount present in the gases escaping from the King's Well, and found that in 10,000 volumes of these gases, there are 12 volumes of helium. Helium, like argon, is one of the "inert" gases, forming no chemical compounds, and therefore without any therapeutic action. Its presence in Continental mineral waters was demonstrated in 1896 by my then assistant, Dr. Travers, and myself, and M. Moureu of the French Academy of Medicine, and M. Bouchard have made extensive researches on mineral waters, chiefly French, and have found helium to be present in larger or smaller quantity in many of them.

The cause of the therapeutic action of such waters has been obscure; mere artificial mixtures of the very ordinary salts which they contain have been said not to produce the same effects as the use of waters fresh from the springs; and it was not evident how the presence of helium, curious though it might be, could be credited with such beneficial results as are undoubtedly produced by "taking the waters."

But in 1903, in conjunction with Mr. Frederick Soddy, I solved the riddle by discovering that helium is one of the products of change of radium, and that its presence in the water is an indication that radium has been concerned in its production. As the chemistry of such substances is quite modern, perhaps a short explanation of what occurs may form a fitting preface to this report.

The element radium was discovered in 1898, in a hard, black mineral named pitchblende, by Madame Curie. She has recently prepared the metal in minute quantity ; it is a hard, white metal, rapidly oxidised by air, and at once attacked by water ; it closely resembles calcium, the metal of which ordinary lime is the oxide, and which is now manufactured on a semi-commercial scale. Like calcium, it forms salts, a few of which have been investigated ; for instance, the sulphate and the carbonate, like those of calcium, are nearly insoluble in water ; the chloride and the bromide are easily soluble. It is now being extracted from Cornish pitchblende in the works of the Radium Corporation at Limehouse in East London, and as bromide it meets with a ready sale at the enormous price of £20 per milligramme, equivalent to more than £500,000 per ounce. For the cure of rodent ulcer, and for certain skin affections, its curative effects are undoubted ; and quantities of from 10 to 100 milligrams are now being bought for use in hospitals and private practice.

Although an element, radium is unstable : that is it is continually changing into another body, also "elementary."

During this change, it parts with helium, each atom of radium furnishing one atom of helium. As atom after atom of radium undergoes this change, miniature explosions take place, the effect being that atoms of helium are shot out with enormous velocity ; they can be recognised by placing near the decomposing particle of radium a small screen of card, covered with a crystalline deposit of sulphide of zinc. As each atom of helium impinges on the screen, a flash of light occurs. That this is the case was discovered by Sir William Crookes ; and Professor Rutherford, by counting the number of flashes, and by other means, too intricate to be described here, has succeeded in demonstrating that each atom of radium emits one atom of helium. These atoms of helium in rapid motion have been termed *a* or alpha-rays. Their therapeutic effect is practically unknown ; but they contain energy, or power of doing work, some 20 times greater than the other radiations termed β (beta) and γ (gamma) which also accompany the decomposition of the products of radium.

Having shot out its particle of helium, the atom of radium is no longer radium, but a gas, to which the name "radium emanation" was given by Professor Rutherford and Mr. Soddy, but which, now that its properties and its atomic weight have been investigated, is better known as "niton." The rate of change of radium into niton is a very slow one. In theory, a given weight of radium should take an infinite time to change completely into niton and helium, because, as the decay goes on, less and less of the radium is left, and that smaller quantity gives off proportionately less niton and

helium. In order to avoid the infinitesimal, it has been agreed to speak of the "half-period of decay," which is a perfectly definite interval of time. An ounce of radium, for example, after a period of 1760 years, would have half changed into niton and helium, while half an ounce of radium would be left unchanged. After a further period of 1760 years, half of the half-ounce, *i.e.*, a quarter of an ounce of radium would be left, the other quarter ounce having produced niton and helium. This process would go on indefinitely, and it is thus evident why the "half-period of decay" has been chosen as a means of measurement.

In collaboration, first with Mr. Soddy, and more recently with my present assistant, Dr. Whytlaw-Gray, I have investigated this gas, niton. Like argon or helium, it is inert, that is, it forms no chemical compounds. In another sense, however, it is not inert, for, as shown by Rutherford and Soddy, it itself has only an ephemeral existence ; in 3.86, or say 4 days, it has half changed. As the activity of these substances depends on their rate of change, niton is a much more potent agent, weight for weight, than radium ; indeed, the potency of radium may be ascribed to the extent of at least 75 per cent. to the action of its product, niton.

Like all other gases, niton is compressible ; it can be converted into a liquid at ordinary temperature by compression alone, and the liquid can be seen in a very narrow-bore tube, as minute in bore as the finest needle is thick ; naturally, a microscope must be used to see the liquid. It is colourless

to look through, like water ; like water, too, it freezes when cooled to a solid something like ice, I suppose ; I say "I suppose," because it is impossible to see the solid as such. Solid niton causes the glass or silica tube in which it is necessary to confine it to glow with a brilliant light, comparable with that of a minute arc-light. The liquid, too, causes the glass to glow with a fairly bright violet light, so that if a tube containing it be looked at in the dark, the violet glow is considerable, but if looked through, against a light, the liquid niton is water-clear. Dr. Gray and I were successful in weighing this gas, and so in determining its atomic weight ; this corresponds to the atomic weight of radium less that of an atom of helium ; and we succeeded furthermore in weighing by difference the helium which the niton had produced in the course of its decomposition into further products.

I have stated that the half-period of decay of niton is about 4 days ; in 8 days only a quarter is left ; in 12 days an eighth, in 16 days a sixteenth, in 20 days a thirty-second, in 24 days a sixty-fourth, and in 28 days one 128th. Practically in a month it has all changed.

Its products, except helium which is a gas, are solids ; they have been named "radium A, B, C, D," etc., by Professor Rutherford. Two reasons have prevented their being investigated ; first, their half-period of decay is too short, and they change before it is possible to handle them : and second, it is much easier to deal with a gas, owing to the much larger comparative volume which it occupies. But it

is known that radium A, B, and C have short periods of decay, such that in three hours they have almost entirely changed into radium D. On the other hand, radium D has a much longer half-period of decay, viz., about 14 years, and no doubt it will be investigated. But from a therapeutic point of view it has little interest, for its change into further products takes place so slowly ; and also without any "rays."

The β, or beta-rays are evolved during the change of radium into niton ; and also during the subsequent changes of radium A and C into radium D. They are of a wholly different nature from the alpha-rays ; they are, to use ordinary language, not reckoned as an element, but are of the nature of negative electricity. Personally, I should be inclined to class negative electricity as a " substance," or as " matter " ; but its properties are unique, and differentiate it from other varieties of matter. The " corpuscles," or atoms of electricity, now commonly termed " electrons," have been largely investigated ; we owe much to the work of Sir J. J. Thomson, who has determined their approximate weight, and the velocity with which they move through space. They are identical, except in rate of motion, with the " cathode rays " produced in the interior of a Rontgen-ray " tube " or bulb. When they are caused to impinge on an " anti-cathode " or piece of refractory metal, they produce what are commonly known as " Rontgen-rays," familiar to all by their power of penetrating flesh and blood, but not so easily bone.

It is the beta-rays which have been chiefly used for therapeutic purposes. While alpha-rays, that is atoms of

helium, like other gases, can be confined in glass or metal vessels, beta-rays pass through ; the amount passing naturally depends on the thickness of the walls of the vessel. The alpha-rays, for example, given off from niton confined in a glass tube do not pass through the glass ; the beta-rays, due to the products of change of the niton do pass through ; and by interposing metal screens of foil of different thicknesses, a greater or smaller quantity may be allowed to impinge on the skin.

A third class of rays is also evolved, during the emission of beta-rays, which have been termed gamma-rays. It is not decided as yet what is their true nature. They have great penetrative power ; indeed, three inches thickness of metallic lead is not sufficient entirely to stop them. They too are sometimes employed for curative purposes. It is suggested that they more resemble rays of light ; that they are not " matter," but waves in the ether which surrounds and interpenetrates all matter.

The Bath Waters.

There are undoubtedly mineral waters which owe their curative power to what may be termed ordinary chemical ingredients ; such are the sulphur waters of Harrogate, Strathpeffer, &c. ; ferruginous waters of various spas ; possibly arsenical waters, and those which contain lithium. But the recorded analyses of the Bath waters show, in the main, merely ordinary constituents, most of which are present in many drinking waters. Sulphates of calcium, of sodium, of

potassium, carbonates of calcium and magnesium, are all common substances. The only unusual constituents of Bath waters, so far as the analysis made at the *Lancet* laboratory shows, are small quantities of strontium, of lithium, and a trace of bromine. But the fact that many mineral waters all over Europe have for ages been used for curative purposes, combined with our present knowledge that such waters, while not remarkable in " chemical " composition, all agree in yielding helium, the product of decay of radium, makes it particularly interesting to examine these waters for niton, as well as for radium itself.

Professor the Hon. R. J. Strutt has already informed the Baths Committee in 1903 of the presence of a trace of radium in the iron deposits left by the waters of the hot springs, as well as in the water itself. No estimations, however, appear to have been made.

In stating results it is convenient to give them as if the waters contained actual radium, even although none may be present as such, but only as niton. We have then all reduced to one standard. It may also be explained that a milligramme is nearly the 30,000th part of an ounce, and that a cubic metre of water may be taken for the purpose of visualising as a cubic yard, or, more accurately, as 30 cubic feet.

Facts regarding the Bath Waters.

Density of the water from King's Well .. .. 1·0166

Osmotic pressure equivalent to that of a salt solution containing per litre— .. .. .. 1·09 gram. NaCl

Volume of gas in 24 hours from—

King's Well	4,927 litres	
Cross Spring	218 ,,	
Hetling Spring	218 ,,	(estimated)
	5,363 ,,	

Analysis of Gas (King's Well.) Parts per 10,000 :—

Carbon dioxide	360
Nitrogen, &c.	9,640

No oxygen; no hydrogen; no marsh-gas.

The nitrogen contains :—

Argon	73·63
Neon	23·34
Helium	2.97

From all three wells in 24 hours :—

Argon	39 litres
Neon	12½ ,,
Helium	1½ ,,

Gases Dissolved in Pump Room Water.

This water contains 18·5 volumes of gas per 1000 of water. Its composition is :—

Carbon dioxide	6·9 volumes
Nitrogen	11·6 ,,

It had become somewhat aerated on drawing ; but allowance has been made for that.

	Milligram per million Litres.
Radium in the water of the King's Well	0.1387
Niton (radium emanation) in ditto	1.73*
Niton ,, ,, Cross Bath	1.19*
Niton ,, ,, Hetling Bath	1.70*
Niton ,, ,, gas from King's Well...	33.65*

I shall now proceed to comment on these facts.

Osmotic Pressure.

The signifiance of this measurement depends, I suppose, on the interchange of the salts in the water with the intestinal fluids ; the salts will tend to pass from where the pressure is higher to where it is lower. I am, however, not competent to give an opinion on such a matter, which has a purely medical significance.

Gas from King's Well.

There are many remarkable features about this gas, one being the absence of oxygen. It occured to me that it would be worth while to test this gas very completely for the presence of hydrogen and marsh gas ; this was done by separating the volatile and non-condensable portion from half a litre of the gas ; but it was found that neither was present.

The estimation of the total volume of gas was made for me by Mr. Jones, the Committee's engineer ; but it appears to fluctuate with the barometric pressure, as well as by the amount of pumping which is going on. I have taken his figures as average ones ; but no doubt observations over a

* These figures are the weights of radium capable of forming the niton present in a million litres of water or gas.

considerable time should be made, in order to obtain a more certain average. It is very considerable, amounting to over five cubic metres in 24 hours.

The most noticeable fact about this gas is the enormous amount of neon which it contains. Neon is present in atmospheric air, which contains the following amounts of the inactive gases.

			Ratio.
Argon	...	93.2 volumes per 10,000 of air	0.78
Neon	...	0.124 „ „ „	188.1
Helium	...	0.0408 „ „ „	72.8

Under the heading Ratio is given the number by which the quantity of these gases in air must be multiplied so as to make them equal to the amounts of the gases in the gas collected from the King's Spring; thus, there is 188 times as much neon in the gas from the King's Spring as there is in an equal volume of atmospheric air.

Neon, I believe, has a certain commercial value, for it is used in filling vacuum tubes for testing the wave-length of the oscillations which serve in wireless telegraphy. There would be no difficulty in separating the neon from the Bath gas, if there proved to be a sufficient demand.

Radio-Activity of the Waters.

My former student, Dr. Makower, has examined the radio-activity of the Buxton waters and gas. The water from the Hospital Natural Baths, and from the Crescent Pump

Room contain each 0·83 milligram per million litres ; it will be seen that the water from the King's Spring and the Hetling Spring are more than twice as rich in niton ; the Buxton water from the " Gentlemen's Natural Baths " contains 1.1 milligram per million litres, which is about the amount contained in the Cross Bath. The gas from the King's Spring contains over 33 milligrams of niton per million litres ; and this is about four times as much as is contained in the natural gas from Buxton, viz., 7·7 and 8·5 milligrams per million litres.

It is, unfortunately, impossible to compare these amounts with statements of radio-activity of foreign waters, for the latter are stated in uncertain units, and it could only be determined in the special apparatus employed by the foreign scientists.

The figures given on page 14 as representing the radioactivity of the waters and natural gas must not be taken for the weights of the niton. They are actually the weights of radium which would produce these amounts of niton. Thus the figure 1·73 means that 1·73 milligrams of radium would be in balance with the amount of niton in the water. This conception is a little difficult, and a few words of explanation are necessary.

Suppose one gram of radium to be dissolved in water, say as chloride or bromide. It is continually giving off niton; but at the same time, the niton is as continuously disappearing, owing to the formation of radium, A, B, C and D.

There will arrive a time when the production of niton from the radium will have ceased to increase, because as it is produced it decays, and the rate of production is then equal to the rate of decay. The amount of niton will therefore increase up to a certain point ; that point is when 0·6 of a cubic millimetre of niton has been produced. The weight of 1 cubic millimetre of niton is almost exactly 1/100th of a milligram, hence 0·6 cubic millimetre weighs 6/1000ths of a milligram. This is the weight of the niton which is in equilibrium with 1 gram of metallic radium. But we have 1·73 milligrams of radium, in equilibrium with the niton in the King's Spring. Hence as 1000 mgrs. : 1·73 mgrs. : : 0·006 mgrs. : 0·0000104 mgr. That is, the weight of the niton in a million litres of the water of the King's Well is about 1/100,000 mgr. But its effect is that of 1·73 milligrams of radium in a million litres. The same reasoning applied to the gas would show that its effect is due to about 1/3000 of a milligram of niton in a million litres ; or in the daily output, 5,363 litres, about 1/600,000th of a milligram of niton, equal in effect to the gas in balance with 1/5th of a milligram of radium.

These figures appear to be ridiculously small; but in must be remembered that the effect of radium is due to radiations of exceeding intensity, and very penetrating ; and at present, although very few observations have been made on chemical change induced by the action of radium and its products, we do know that considerable changes are produced

under the action of quantities of radium comparable with the amounts given above.

Use of the Waters and the Natural Gas.

Experiments which I have made in conjunction with Dr. Stevenson in the Medical School at University College, in which mice were fed with bread and cheese soaked in a solution of niton, and in which kittens were injected with a similar solution, as well as fed with it, have shown that the niton is got rid of chiefly by the lungs, and that in about three hours. After twelve hours all traces have disappeared. It may be that when a patient takes a bath, the skin absorbs some niton ; and some undoubtedly enters the lungs, for it is continually being given off from the surface of the hot water. Assuming this to be the case, it may be asked whether there is any means of increasing the dose taken by each of these methods of absorption.

Considering first skin absorption, this might be greatly increased in the following way :—You already have a very pretty installation for giving "electric baths." But the current is an alternating one ; it may and undoubtedly does produce electric stimulus ; but the fact of the rapid reversal of the current prevents any concentration of niton on the skin. Now, niton in disintegrating is continously discharging electrons, or in the older phraseology, losing negative electricity, and becoming positively charged. It follows that it will be attracted by a negatively charged body. If the patient in the electric bath were connected with the negative pole of a

battery giving, say, 100 volts potential, or even more, and the other electrode were placed in the water, of course not in contact with the bather, the niton would rapidly reach the skin. It is, indeed, not unlikely that it would enter the system by so-called "ionisation," and in this way a considerable dose might be given. The apparatus would require the substitution of a continuous for an alternating current, and suitable measuring instruments, but this would entail no great expense. Naturally, any experimenting on these lines would require to be made with caution; I do not know of any attempts in such a direction. I suppose that such a bath as is in use may contain about a cubic metre of water; if that be so, then the amount of niton in the bath would be about the thousandth part of the figures given above. This amounts roughly to the equivalent of the thousandth of a milligram of radium, and even if it were all absorbed, it could not, judging by the results of the experiments on kittens, prove a dangerous dose.

Coming next to the administration of much stronger doses, that is in your power. There is an ingenious spraying machine, constructed, I am informed, by Mr. Jones, chiefly used, I was told, for throat affections. This is fed with air, or with air and steam, carrying with it the natural water. Now, if the natural gas were used for this purpose, an agent nearly twenty times as potent would be available. I fancy that the spray produced by forcing the gas under pressure through the water could be employed directly against the skin. It occurs to one that that might prove efficacious

in the treatment of local rheumatism. If, at the same time, the patient were insulated and connected with the negative pole of a battery, the chances of absorption would be greatly increased. There would be no difficulty in arranging such an apparatus. It might be possible to make the patient breathe the spray, for absorption by the lungs would no doubt be very rapid ; but this, I think, should be tried with caution.

The total quantity of niton available in the gas from the King's Spring in 24 hours is the equivalent of about 0·17 of a milligram of radium. In a room 15 feet cube there would be little more than the thousandth of a milligram per cubic yard. I am afraid that ventilation would be defective were it arranged to allow the niton to accumulate in a room in which people would assemble to breathe it. It would appear to be preferable to administer it in the form of spray.

I append a copy of the complete analysis of the water from the King's Spring, conducted by Mr. I. Masson and myself.

Lithium ...	Li	...	0.16	Milligrams per litre.	
Sodium ...	Na	...	181.1	,,	,, ,,
Potassium ...	K	...	16.7	,,	,, ,,
Magnesium ...	Mg	...	4.1	,,	,, ,,
Calcium ...	Ca	...	335.7	,,	,, ,,
Strontium ...	Sr	...	3.2	,,	,, ,,
Iron ...	Fe	...	40.2	,,	,, ,,
Aluminium ...	Al	...	9.7	,,	,, ,,
Arsenic ...	As	...	trace	,,	,, ,,
Chlorine ...	Cl	...	154.8	,,	,, ,,
Bromine ...	Br	...	4.4	,,	,, ,,
Sulphuric Radicle	SO_4	...	1054.0	,,	,, ,,
Carbonic ,,	CO_3	...	15.8	,,	,, ,,
Salicic ,,	SiO_3	...	—	,,	,, ,,
			1819.86		

Wm. RAMSAY.

Sir William Ramsay submitted the results of his investigations of the Hot Springs in a Lecture given in the Grand Pump Room, at Bath, on March 11th, 1912, before the Mayor and Corporation of Bath, Members of the Medical Profession and others.

Sir William Ramsay made the following verbal additions to the Report given above.

It has been known for a considerable number of years that helium, which I discovered in 1895, exists in the Bath waters. Helium is not quite the lightest of gases, for that distinction belongs to hydrogen, but it has an atomic weight smaller than all the rest and only four times that of hydrogen itself. The liquid into which helium has quite recently been condensed has the lowest boiling point known, and this gas has the further characteristic of giving a very brilliant yellow line when seen through a spectroscope.

The chemical evidence brought forward at the time of the helium discovery was such as to make it probable that there existed other gases resembling helium and argon, and therefore an extensive examination was made upon various mineral waters. I went to Iceland and collected samples of gas from the volcanic waters in that country. The waters of continental spas were examined, as well as those of spas in this country. In some cases, as at Harrogate, there

proved to be no helium ; in others, as at Buxton, helium was present. The amount of helium present in the gases escaping from the King's Spring at Bath was estimated by Lord Rayleigh to be 12 volumes in ten thousand.

The cause for the therapeutic action of certain of these waters has been for a long time a mystery. Ordinary chemical analysis in many cases fails to reveal any remarkable constituents. The value of some waters is, of course, easily explained on the ground of their sulphur content ; others are ferruginous ; a few contain lithium, which may have a medicinal action, probably on calculus ; others, again, as in the case of Royat, Auvergne, in Central France, contain arsenic. But it is not easy to see how waters containing perhaps ordinary carbonate of lime and some common salts like those which are present in many drinking waters, can have any particular value from the medical point of view.

Nor did the discovery of helium in these waters explain it. Helium is an inert gas, it has no chemical affinities, and therefore no therapeutic action. The problem remained unsolved until, in 1903, working with Mr. Soddy, I found that helium is evidently a product of change of radium, and that the presence of helium in a water implies, either that radium is present in the water itself, or that the water has been, at one period or another, in contact with radium.

The discovery of radium has compelled us to re-

define an element. Originally an element was considered to be the final material—the material which was not further resolvable. Nevertheless, chemists of authority have always made a reservation in this respect. They have stated that an element consisted of "that which has not yet been decomposed," and the result proves that their caution was justified. Although an element, radium is unstable; that is, it is continually changing into another body, also elementary. One of the elements into which radium changes is helium, and the other element is known generally as "radium emanation." Each atom of radium furnishes one atom of helium.

The discovery of the radium gas or emanation was made by a German named Schmidt, and at first it was looked upon as a kind of influence more than anything else. Rutherford and Soddy, however, set to work and made some electroscopic investigations, and these have been followed up very closely, so that now we are compelled to consider the radium emanation as being in a sense an element. It behaves as a form of matter which has a certain stability and lasts for a certain length of time. It can be converted into a liquid by compression, and the liquid can be seen in a tube having as fine a bore as a clinical thermometer. The spectrum of radium emanation has been mapped out, and its atomic weight, which is about 223, has been determined, so that it is now convenient and justifiable to supersede the clumsy term

"radium emanation" with the name "niton," from the Latin *nitere,* to shine or glisten.

We have considered that each atom of radium undergoes a little explosion, expelling an atom of helium, which moves with a velocity equal to one-third the velocity of light. When this has taken place the atom that was originally radium is now no longer radium, but niton or radium emanation. The atom of helium, as I have said, corresponds to the alpha particle of the alpha ray. There is some ambiguity in the use of the word "ray," for a ray may mean a particle shot out from the body emitting it or it may mean equally a set of vibrations. Sir Isaac Newton made a clear statement upon this point. He believed that light might be either of these things—emitted particles or undulations in the ether. So far as light is concerned we may consider either view. But the alpha ray, whose emission implies a change into helium on the one hand and to niton on the other, differs fundamentally from the other rays of radium—the beta and gamma rays—in being a particle of matter.

Franklin, who brought down electricity from the skies, was the first to develop a theory of electricity on the basis of negative and positive. Unfortunately, what is called negative electricity represents the surplus and positive the deficit, instead of the other way about. What is electricity? As at present understood, it appears to be a form of matter, differing from other forms of matter simply

by reason of the fact that the atoms are very much smaller. One atom of electricity, which is called an "electron," represents about one 1,700th part of the weight of an atom of hydrogen. Here we have, therefore, another form of matter which moves through space, and which we cannot confine in a vessel because a vessel is too porous, but which can be recognised when in motion, or even when not in motion, by its effecting strains between different kinds of matter. We owe much of our knowledge of the electron to the work of Sir J. J. Thomson, who has determined its approximate weight, and the velocity with which it moves through space.

Although the Bath water does contain a trace of radium it contains a great deal more niton. The usual way of stating the amount of niton, is to give a certain quantity of radium with which the niton can be said to be in equilibrium. Radium, we must remember, has a very slow period of decay, and niton has a very fast period. If we free a solution of radium from niton by boiling, and boil all the niton away, the radium will go on decomposing, and thus niton will gather again and accumulate. The accumulation, however, will stop after a certain point, because remember, the niton itself is decomposing. After about thirty days the radium will have produced as much niton as it can in view of the fact that it is decaying during the whole time. That represents the point of balance or equilibrium.

Therefore, in dealing with the radio-activity of the

Bath waters, I propose to give the figures according to the amount of radium with which niton is in equilibrium. The results are given as though the waters contained actual radium, even though none may be present as such, but only as niton. Thus it is all reduced to one standard. When we say that there are 1.73 milligrams of niton in the water of the King's Spring we mean that 1.73 milligrams of radium would be in balance with the amount of niton in the water.

The amount of radium in the water of the King's Spring represents only about one 470th part of a grain in something like two hundred thousands of gallons. The niton, however, is present in much greater quantity, and I have been greatly surprised at the amount of niton which issues from the gas of the King's Spring. The amount of niton is that which would be in equilibrium with 33.65 milligrams of radium in a million litres of water.

The figures which show the amount of radio-active substance available appear ridiculously small. But it must be remembered that the effect of radium is due to radiations of exceeding intensity, and very penetrating; and at present, although very few observations have been made on chemical change induced by the action of radium and its products, we do know that considerable changes are produced under the action of quantities of radium comparable with the amounts I have given.

For my own part, I am becoming rapidly converted to the essential principle in homœopathy by the reading of recent years. Two examples of the effect of the infinitesimally small will suffice. In the *Comptes Rendus* of the Académie des Sciences only last week there was an account of some experiments made by a chemist upon a particular kind of mould. The chemist finds that if an amount of manganese equal to only one 500,000th of the weight of the ash be introduced, the mould will double in weight within a certain time, and that if this infinitesimal quantity be omitted it will not. Again, take the disease known as myxodoema, which is due to a deficiency of thyroid gland secretion. The thyroid secretion has been proved to contain arsenic and iodine. We are not aware of taking arsenic and iodine in our food, but we must take it, otherwise the thyroid gland would not secrete a suitable material, and the result of a lack of thyroid secretion is to produce myxodoema. The amount of arsenic and iodine is infinitesimally small but physiologically intense. And, of course, we are getting inured to the fact of the mischief produced by the infinitesimal in the form of micro-organisms.

I have been asked whether it can be said that the water is saturated with niton. The answer is; Yes. The gas coming from the water contains much more niton than the water itself, and therefore the water contains as much as it will hold at the very high tem-

perature of about 120° Fahr., at which it comes out. But this conception of saturation requires to be elaborated a little. Take the case of air. Air is soluble in water, not as air, of course, but in the form of its constituent gases, oxygen and nitrogen. Air consists, roughly, of one part of oxygen and four parts of nitrogen. Nitrogen is soluble in water to the small extent of about one per cent. Oxygen is much more soluble—four times as much. Now, on compressing air into water, what would be the relative amounts of oxygen and nitrogen dissolved? To arrive at the figure it is necessary to multiply the proportion in which they are present by their solubilities. There are four parts of nitrogen and its solubility is one. Therefore: $4 \times 1 = 4$. There is one part of oxygen and its solubility is four. Therefore: $1 \times 4 = 4$. Therefore the dissolved oxygen and nitrogen, which bore the proportion of one to four in air, are in equal proportion when dissolved. Let us suppose another case. We have, for example, one part of oxygen, and ninety-nine parts of some gas having a solubility of four. In that case we have the proportion of 396 dissolved parts of the one to four dissolved parts of the other. But the water would still be saturated with oxygen to the full extent of the oxygen solubility. The same idea of saturation applies in the case of the radium emanation, although the amount of emanation is extremely small and the amount of nitrogen is enormous. The water will take up as much emanation as it can, having regard to its solubility, and therefore it can be said to be saturated.

RADIO-ACTIVITY AS A FACTOR IN THE EFFICACY OF THE BATH MINERAL WATERS.

Contributed by the Bath Branch of the British Medical Association.

Balneologists have always inclined to the belief that the beneficial effects of Spa treatment must be in part due to some other factor than the known properties of the substances contained in the various mineral waters employed. What this factor might be it has, however, been impossible to surmise until the recent discovery of the radio-activity of mineral waters, as well as of sea and spring water, has supplied a tenable clue to the mystery. The investigations hitherto conducted by His, Gudzent, Löwenthal and others have been mainly concerned with the effects of radium tubes and artificially-prepared radio-active solutions, while comparatively little has been done with regard to mineral waters. Yet it may be of interest briefly to summarise the main results of such investigations, which may be provisionally accepted as contributions to rational balneotherapy.

In the first place there is a consensus among most experimenters to the effect that under the influence of radium

there ensues an increased activity of all the processes of nutrition and metabolism. Increased oxidation is evidenced by a rise in the percentage of all urinary solids other than the chlorides. There may also be a considerable multiplication of the red blood cells. The improved nutrition may be in part due to the increased activity of the peptic and pancreatic ferments, which has been verified by several observers. A similar augmentation of the various autolytic, diastasic and glycolytic ferments has also been observed. Some difference of opinion exists with regard to the question of the bactericidal effects of radium and its derivatives. The chief German authorities are inclined to deny these, but, on the other hand, the experiments of Wickham, Russ, Barlow, Dr. and Madame Fabre, and Ostrowsky tend to show that the growth of micro-organisms is in some way retarded, if not inhibited, by radium emanations. In view of the marked success that has been obtained at Bath in the treatment of gonorrhoeal arthritis, it is an interesting fact that the antibacterial or bactericidal effect of emanations is particularly marked in the case of gonococci. In connection with this question of the bactericidal effects of radium emanations, reference may be made to their power of stimulating the elimination of toxins, a power manifested by increased toxicity of the sweat.

Seeing that a very large proportion of the patients who undergo mineral water treatment at Bath and elsewhere are the subjects of arthritic and other maladies associated with an excessive production or a defective elimination of uric acid, great interest attaches to the experiments of Gudzent and

others upon the action of radium emanations upon uric acid itself as well as upon patients in whose blood it could be demonstrated. Laboratory experiments prove that under the influence of radium emanations the insoluble monourate of sodium can be changed into a soluble monourate which subsequently decomposes into ammonia and carbon-dioxide. In thirteen out of fourteen cases of gout treated by Gudzent in his emanatorium the blood was freed from uric acid; and the same result was obtained by His in fifteen out of eighteen cases, the blood of the remaining three showing no change.

Morlet, who has recently recorded the results obtained by him at Antwerp in a series of cases treated by emanations, finds it advisable to warn gouty patients of the probability of an access of gout appearing between the tenth and fifteenth day of treatment. A similar exacerbation of symptoms is a common incident of spa treatment, perhaps due in part to the same cause. The reaction, if not very severe, should rather be welcomed as a sign of progress than allowed to interrupt the treatment. F. Gudzent who has during the past three years treated 400 cases of gout and rheumatism with radium emanations, has also noted the frequency with which painful reactions and acute exacerbations occur after a week or two of treatment. Such reactions are as a rule soon followed by marked improvement.

The conditions which were most favourably influenced by the treatment were simple chronic arthritis, chronic muscular rheumatism, progressive polyarthritis, (rheumatoid?),

infantile arthritis and gonorrhoeal arthritis. It is interesting to note that Gudzent recommends the prescription of the emanations in drinking water. Other authorities advocate in certain cases the hypodermic injection of radio-active solutions, and rectal or vaginal irrigations. It is more than likely that the beneficial effects of the routine drinking of the Bath Mineral Water, as well as of its use for vaginal and rectal irrigation, may be partly attributed to its radio-active quality. It is also a fact worthy of mention that the radium treatment of gouty conditions has been observed to result not only in a clearance of uric acid from the blood but in restitution of the normal power of uric acid elimination. In addition to the results already mentioned, treatment by radium emanations (niton), with which the Bath Waters are impregnated, has been found to reduce blood-pressure, especially in arterio-sclerosis ; to produce marked benefit in albuminuria, diabetes and glycosuria ; and to increase sexual vitality. In view of the last-named effect, and assuming the accuracy of Engelmann's proof that in the bathing method a certain part of the emanation is absorbed through the skin, the custom in vogue now at Leukerbad, and formerly in Bath, of spending many hours in the bath, would seem to have a rational basis.

Although it is unlikely that the immersion method will ever be superseded at Bath, it will probably be supplemented in the near future by others designed to utilise the 5,000 litres of highly radio-active gas which are here daily available. Sir William Ramsay considers that, when a patient is taking

a bath, in addition to the niton that may be absorbed by the skin, some undoubtedly enters the lungs. He has recommended a form of electric bath which would considerably augment the cutaneous absorption of niton by means of ionisation. And, in cases where an even larger dose may be required, he recommends the inhalation of local application of vapour spray, similar to the form now in use here, fed with natural gas in addition to the mineral water, by which means an agent nearly twenty times as potent is available.

With regard to the contra-indications of radium-therapy; most authorities agree that it should be avoided in all tuberculous conditions. Good results might naturally be expected in cases of gouty glycosuria; and have also, as mentioned above, been claimed for diabetes. But in view of the tendency of radium emanations to stimulate metabolism, the latter claim appears to be questionable. Löwenthal considers chronic nephritis of the contracted type a definite contra-indication. The subject is obviously one for further investigation.

ON THE BALNEOLOGICAL ASPECT OF RADIUM.

An Address at the Balneological Congress held in Budapest, April, 1912.

By PROF. EDE WEISS, M.D.,
Vice-President of the Balneological Society, Budapest.

From "The Medical Press," 5th June, 1912.

It is some five years since investigations were made in Hungary relating to the radium contents of some mineral waters; these investigations resulted in the discovery that in rheumatism and gout the efficaciousness of a certain water is in direct proportion to its radium content. They found that even the celebrated mineral water aperients contain more or less radium, this contributing to their action in a fairly large measure. The investigations have also shown that the emanation is possessed of the nature of a volatile gas, consequently it evaporates very quickly, and it gets transformed also in a closed jar, so that in three or four days not even traces remain. This fact, which seems to prove the advantage of using mineral waters at the very spring, and the

fact that sometimes on patients being treated with artificial emanations, similar reactions are seen to those occurring in some watering places, have led to the justifiable conclusion that among the active elements of the mineral waters radium occupies an important place. Even some over-enthusiasts proclaimed the extreme view that radium is not only the most important, but, so to say, the exclusive acting principle of most mineral waters.

However, this is a great mistake. At the German Balneological Congress of last year, I clearly demonstrated that it is a mistake to identify any complex mineral water exclusively on the ground of its radium content with, say, an ordinary well-water artificially activated with emanation. This exaggeration will necessarily lead from one side to the over-estimation of emanation, and from the other side to the neglect of the physical and chemical components of the respective mineral waters. If we reflect how not indifferent on the skin and mucous membranes the temperature and the quality and quantity of the salts contained therein are, it is very easy to understand that a mineral water, capable of producing hyperæmia by reason of its temperature and its qualities and at the top of these by its emanation of radium, is particularly apt to provoke near and far reflex action. And so it seems that balneology in its rejoicing with its new-born baby, radium, is apt to forget that it is not decent to treat its other children as a stepmother. . . .

Beyond the mentioned different methods of external application recourse has been taken in internal medicine also to other possibilities of application. Nominally, besides the baths containing emanation, drinking cures and inhalation with air saturated with emanation have been introduced.

As for the baths, the majority of authors agree that emanation does not get into the organism through the skin, but it exclusively gets into the blood through the lung, which absorbs the emanation just as eagerly and as quickly as it discharges it.

However, in opposition to these facts, some authors are arguing on grounds of their own experiences, that if the baths are taken for a sufficiently long time, then considerable emanation-quantity reaches the organism through the skin,

It is an old and most-discussed question of balneology—what can the skin absorb and what not? The absorbing capacity of the skin in general being very moderate, there is some difference of opinion ruling in this matter, though through skin irritation we are able to produce extraordinary effects from the outside, without the respective matters having become absorbed through the skin. And thus, without doubt, emanation products must have effect through the skin too.

As to the drinking cure, it became clear that the emanation having got into the stomach, it gets quickly

enough into the blood-current by way of absorption, and is discharged in from three to four hours with the expired air. Therefore it is a general rule to order a drink cure three or four times a day, in order that thus the juices of the body should stand under the longer emanation action.

In the ranks of the historical order the inhalation system is the last one, but in respect of efficaciousness its prominence brought it easily in the front row.

This latter fact shows what extraordinary importance natural basin-baths may have from the point of view of emanation-inhalation, and particularly valuable are those which, by reason of their contents, continually fill the air with emanation, like an immense emanatorium.

. . . . .

As to the mutual relation of drinking and inhalation cures, I agree with Dr. Plesch, of Rajecz, Hungary, who has demonstrated that the blood takes up about 10 per cent. less emanation than water; therefore the emanation behaves itself towards the blood just as a strange gas. The emanation content of the blood rises in direct proportion to the tension of the emanation and the time of exposure; the emanation content is the greater, the quieter the respective individual is. Whilst through inhalation the emanation gets into the capillary vessels of the lung and hence into the whole body, with a drink cure it gets from the intestines through the liver into the vena cava inferior; or through

the ductus thoracicus into the vena cava superior, that is to say, into the lung, whence it is discharged with the breath, without circulating in the whole body. By reason of this fact Plesch suggests the combination of inhalation cure with the drink-cure.

. . . . .

As for the therapeutic value of radium and its emanation at present, there is no doubt as to its usefulness in dermatological cases, some neoplasms, and neuralgias. I, for my part, have been particularly interested to observe the results of emanation in rheumatic and gouty affections. The last contribution on this subject appeared in the *Berliner Klinische Wochenschrift* from Professor His, who describes his experiences with 100 chronic rheumatic patients and 28 gouty cases. The patients have been treated in the Löwenthal inhalatorium *recte* emanatorium; of course, combined with the strictest diet and regimen. As regards these mentioned rheumatic patients, it seems, as far as I can judge from His's statistical data, the results cannot be compared with those attained in corresponding thermal baths, as, for instance in Pöstyén, though it is to be admitted that in some exceptional cases the results have been surprising. According to His, the result is the greater the younger the subject and the fresher the case. In gout, the results were paramount not only from a practical point of view, but they were extraordinarily interesting also theoretically. Among 28 patients, only four did not improve, all the others improved

considerably. The chief moment was when the uricæmia did accurately cease in 15 out of 18 cases—that is to say, while before treatment uric acid could be traced in the urine, after a couple of weeks it entirely disappeared from the blood. There were only two or three who were refractory to treatment.

RADIUM EMANATION AND PHYSIOLOGICAL PROCESSES.

Being a Paper read in the Section of Electro-Therapeutics and Radiology at the Annual Meeting of the British Medical Association, Birmingham, 1911.

By DR. S. SAUBERMANN,
Charlottenburg, Berlin.

From "The British Medical Journal," October, 14th, 1911.

Dr. Saubermann reviewed the now familiar atomic processes of radium disintegration, and claimed that the gaseous element or emanation which made its appearance almost in the centre of that series was the real producer of the wonderful ray-emissions which characterised the successive steps. The so-called radium-therapy, in his judgement, was nothing but an emanation-therapy. . . . .

The mere presence of radium emanation either initiated or intensified chemical processes, especially that

of oxidation; while biologists had shown that relatively large quantities of emanation caused a diminution of cell dividing and regeneration, and delayed embryonic growth. As to physiological effects, he regretted that for a long time the striking discoveries as to the connection between emanation and organic metabolism made no impression upon practical medicine. From the year 1903 he advocated the opinion that the well-known effects obtained at natural spas were not derived from physical forces, but resulted from the increase of chemical action, especially oxidation, owing to the presence of radium emanation in the waters.

. . . . .

The remainder of Dr. Saubermann's address consisted of a very long extract given by permission, from the findings of Professor Lazarus, of Berlin. Since this extract was regarded by Professor Saubermann as the main part of his own lecture before the Section, we quote from it somewhat extensively:

Radium emanation can enter the organism in several ways, but in accordance with the character of an inert gas it totally and rapidly leaves the body. The main portion leaves through the lungs, a large part through the intestines, and some through the skin and kidneys. The manner of entering decides the degree and speed of the emanation-passage through the organism. It lasts *seconds* by inhaling; *minutes* with an injection; *hours* with the

stomachal or rectal application. Consequently we distinguish five ways of absorbing emanation :

1. Through the lungs.
2. Through the digestive organs.
3. Through the skin.
4. Through the medium of different forms of injections.
5. Through the employment of local applications externally, on wounds for instance.

" The lung is the quickest medium of absorption and discharge of the radium emanation. The large resorptive surface of the alveoli facilitates a direct indrawing into the circulating lung-blood with each breath. Here the radium emanation, in accordance with the laws for indifferent, respirable gases, is physically dissolved, but a chemical composition, as, for instance, that of carbon oxide, does not take place. Therefore, the absorption of the radium emanation is dependent, like all other gases foreign to the body, on the coefficient of absorption, the temperature, and partially on the pressure. The solubility of the emanation in blood is less, like all salt solutions, than in water of the same temperature. . . . The emanation penetrates from the air that is breathed into the alveolar air, from thence into the blood, and with the blood into the organs and tissue cells, which, in accordance with their specific solubility, will take up the emanation. The more regular the concentration of the emanation, the sooner there will be reached a saturation of the blood, in con-

formity with the duration of inhalation. At the moment when the admission of the emanation ceases, the curve changes its direction; the emanation leaves the blood and enters the air of the lungs and the tissues, and in a short time the whole of the body emanation diffuses to a large extent through the alveoli."

After noting that the kidneys, intestines, and skin are also the media for the excretion of the breathed-in emanation, Professor Lazarus went on to speak of the emanation administered per os, which, he said, entered the organism in three ways. The first represented the direct penetration of the stomach and intestines; the second, diffusion into the capillaries of the lymph and portal vein systems, the emanation circulating through the liver; the third, a method which he termed "retrospiration." As to this last, his tests left no doubt that a very large portion of the emanation imbibed reached the arterial blood. Emanation certainly circulated with the blood, whether administered per os or per pulmones. By inhalation the emanation reached primarily the lungs, and secondarily the intestines, but the opposite took place in the drink cure. The difference between the two resided principally in the speed of the emanation's passage. Though the emanation was absorbed more rapidly in the case of primary inhalation, it would be retained scarcely so long as it was being breathed, but in the case of the drink cure the emanation was gradually introduced into the circulation, and it left the system also relatively

slowly. It was obvious, therefore, that the emanation circulated only for so long in the blood as it was being absorbed by the organism. The speed of resorption and the tendency to diffusion of emanation within the organism was very great. . . . .

The following Physiological Observations have been made with Radium emanations.

All increased radio-activity in mineral springs makes itself felt in the human organism, a physiological factor which cannot be ignored. — *Bergell, Bickel, and Himstedt.*

The higher the emanation capacity of a given spring, the more striking are the physiological results.

Maché, Curie, and Laborde.

Occurance of bladder activity, increased diuresis, and exacerbation of pains in baths with radio-active water.

Neusser Saake, and Wilke.

Radium emanation has a favourable effect upon organic metabolism. *Deutelmoser, Saubermann, Silbergleit, and Kijokki.*

Increase in the excretion of urea up to 34 per cent., and of uric acid up to 14 per cent. *Wilke.*

The cardiac, blood pressure, diuresis, excretion of urea and uric acid are influenced.

Deutelmoser, Saubermann, and Krieg.

Radium emanation lessens blood pressure and cardiac activity. *Deutelmoser and Saubermann.*

Radium emanation has the power of keeping the uric acid compounds in their easily soluble forms.

Deutelmoser and Saubermann.

Radium emanation acts both as a powerful nerve sedative and as an hypnotic. *Pollack and Dreuw.*

ANALYSIS OF THE SPRINGS.

The following important observations on the chemistry of the Bath Springs are extracted from the report of the special commission appointed by the *Lancet* some few years ago:—

The thermal springs of Bath are three in number. It is probable that they have a common origin, but the three outlets are perfectly distinct, though they are within short distances of each other. The temperature differs only three degrees, the hottest, the Old Royal Spring, being 120° F. The chemical composition of the waters is analogous, but there are some differences in the amount and ratio of the constituents of the three waters. The interesting

question relating to the explanation of the formation and origin of the thermal waters is one with which it is hardly within our province to deal.

The following analysis of the King's Spring was made at the *Lancet* laboratory :—

	Grains per gallon.	*Centigrams per litre.*
Calcium sulphate ...	102·880	146·97
Strontium sulphate ...	2·030	2·90
Sodium sulphate ...	23·500	33·57
Potassium sulphate ...	0·207	·30
Calcium carbonate ...	8·750	12·50
Magnesium chloride ...	15·800	22·57
Sodium chloride ...	9·080	12·97
Lithium chloride ...	0·120	·17
Silica	1·960	2·80
Bromine	traces	traces
Nitrates	none	none
Carbonate of iron ...	1·600	2·29
Total Mineral matters .	165·927	237·04

Other investigations have been made by eminent scientists. Lord Rayleigh's examination of the gas from the King's Spring showed that it contained 12 parts of helium per 10,000 volumes.

Professor Sir James Dewar, F.R.S., in 1897, succeeded, by the process of liquefaction by freezing, in separating a large quantity of helium from the gas. Sir James Dewar's examination also showed that argon was present to the extent of about 140 parts per 10,000.

In 1903 the Hon. R. J. Strutt, F.R.S., detected the presence of radium in the deposit from the Springs and, early in the following year, in the Waters themselves.

The existence of the extremely rare elements krypton and xenon in the gases given off by the Springs has also been demonstrated by Sir James Dewar.

THERAPEUTIC ACTION OF THE BATH WATERS.

It is difficult to estimate the relative therapeutic values of drinking the waters and bathing in them, as the two methods are usually adopted simultaneously.

When fresh, the water is clear and sparkling, without odour, and with a very slight saline chalybeate taste which is by no means unpleasant. The quantity to be taken is, of course, regulated by the physician. As a rule from ten to twenty ounces are ordered daily, but more is frequently required, especially in those cases where a general flushing of the system, a washing out of the alimentary canal, and a dilution of the secretions of the liver and kidneys is desired.

Quoting once more from the *Lancet* special commission :—"The thermal waters of Bath exert a distinct solvent action on uric acid. In our experiments, for example, it was shown that Bath water dissolved over five times the amount of uric acid that distilled water would similarly take up at blood heat, i.e., just under 100° F. Since the waters are drunk hot and used hot for bathing purposes this fact may have an important relation to the therapeutics of Bath waters in the treatment of chronic gouty affections and rheumatism."

The therapeutic action of the waters depends partly, no doubt, in common with ordinary water, upon the quantity taken. Beyond this, however, it has undoubtedly a peculiar value of its own, due in all probability to the marked radio-activity it possesses.

It is a distinct diuretic, its therapeutic use in this direction being beyond question ; and it has also a special solvent action upon urinary concretions, particularly renal calculi. It is probably upon these qualities that much of its virtue depends in the treatment of gout, not only in the orthodox forms of that disease, but also in its many irregular manifestations, and in those other joint affections also which result from the arthritic diathesis. In connexion with these remarks the experiments recorded in the *Lancet* analytical report as to the solvent action of the waters on uric acid are suggestive. The waters also contain a very small quantity of iron in a very assimilable form but the improvement in anæmic conditions which is brought about by a course of the waters may be partly attributable to a thorough irrigation of the tissues and the removal of toxic material, as well as to the small percentage of iron in the waters.

Taken in suitable quantities the Bath waters increase the appetite and improve digestion.

The value of the mineral waters in causing the diminution and disappearance of sugar in cases of "gouty" glycosuria in the middle-aged has been amply demonstrated and constitutes one of the most valuable properties of the water.

CASES FOR WHICH THE RADIO-ACTIVE WATERS OF BATH ARE INDICATED.

A brief list of the diseases most frequently and successfully treated at Bath is given but for more detailed information, the reader is referred to the Medical Handbook to the Hot Springs, published by the Corporation.

Gout in all its forms, the various varieties of so-called fibrositis or "chronic rheumatism" (chronic articular rheumatism, muscular rheumatism, senile arthritis, morbus coxæ senilis, etc.) and gonorrhœal rheumatism, yield highly satisfactory results. The majority of cases of rheumatoid arthritis derive considerable benefit.

Stiffness and limitation of movement following injury to joints rapidly improves under a course of the Baths.

Certain disorders of the digestive organs are often much relieved and muco-membranous colitis is very successfully treated.

In cases of chronic gastric catarrh, associated with hyper-acidity and secondary fermentation of carbohydrates, the water may be given freely with considerable benefit ; in debilitated patients with gastric atony and deficient secretion the amount requires to be cautiously regulated.

Arterio-sclerosis is treated in the premonitory or pre-sclerotic stage and also in the later stages if the deeper organs are not much involved.

Very good results are obtained in some diseases of the skin, notably psoriasis, eczema and acne, and especially if the condition is of gouty or rheumatic origin.

Sciatica is very successfully treated and diseases of the nervous system, chorea, peripheral neuritis, neurasthenia, etc., yield good results.

The Mineral Water in an atomised form, sometimes in conjunction with the radio-active gases, is very successfully used in the treatment of gouty and rheumatic laryngitis, hypertrophic laryngitis, chronic rhinitis and in general treatment of the nose and naso-pharynx.

Various diseases of women yield satisfactory results, especially interrupted or painful menstruation. Cases of leucorrhœa, cervical catarrh, and chronic pelvic induration also experience benefit. Chronic inflammation of the ovaries is sometimes relieved by suitable baths and douches.

Definite improvement follows a course of the waters in simple anæmia and chlorosis.

As a resort for tropical patients Bath has a long-established reputation. The waters rapidly benefit cases saturated with the poison of malaria, and improve the cachetic condition.

Lead poisoning yields good results.

Contra-indications. Acute conditions of joints, tubercular arthritis ; advanced cardiac disease aneurism.

METHODS OF APPLICATION.

Detailed descriptions of the various forms of baths and douches in use at the Hot Mineral Baths are to be found in other publications issued by the Bath Corporation. A few notes, on some of the principal methods only, are given here.

The Radio-active Waters are served for drinking in the Grand Pump Room and, during the Summer Season, at the Colonnade Fountain in the Institution Gardens.

For external application the Waters are administered in the extensive Bathing Establishment.

The high temperature at which the Water issues from the Springs enables baths and douches to be given without any necessity for artificial heating, with its risk of interfering with the therapeutic effect of the natural radio-active waters.

The Deep Baths have always been a special feature of the Bath system. Some of these are fitted with hydraulic chairs for gently lowering helpless patients into the water. In almost all cases the under-

current, or *sub aquas,* douche forms an important part of the treatment.

Reclining Baths are used in certain cases instead of the Deep Baths. These are also provided with douches for use either above or under water.

Douche-massage, both on the Aix-les-Bains and Vichy systems, is very largely employed, the natural hot mineral water being specially adapted for this form of treatment.

Local douches and the Scottish douche, as well as needle, spray, ascending and other douches are given.

The Berthollet, or natural Vapour Bath, may be local or general. The whole body, or a single joint, can be submitted to the influence of the vapour derived from the thermal waters.

The Intestinal, or Plombiéres Douche, for muco-membranous colitis and similar diseases is largely and successfully employed. The Radio-active Waters of Bath appear to be specially suitable for this form of treatment.

The special douching, as carried out at Bourbon-Lancy, for reducing high arterial tension has been installed. Many other forms of treatment are given, such as Electric Hot-air Baths and Hydro-electric Baths, Nauheim treatment, and Sulphur and other Medicated Baths.

Medico-mechanical exercises for joints and muscles are given by means of the ingenious machines of the Zander Institute.

Large and well-appointed Swimming Baths afford an agreeable, and no less valuable, form of bathing in cases where patients are ordered a free use of their limbs. The temperature is maintained at about 84 by a constant flow of cooled mineral water.

Sir William Ramsay's recent investigations of the Hot Springs have shown the Bath Waters to be the richest in Great Britain in Radium, and its even more potent emanation—Niton.

It may be well to repeat the principal figures :—

	Milligrams per million litres.
Radium in the Water of the King's Spring ..	0·1387
Niton (radium emanation) in ditto	* 1·73
Niton (radium emanation) in natural gas from King's Spring	*33·65

These important scientific discoveries have been been followed by the addition of new methods of applying the waters in the cure of disease. In the recently opened Radium Inhalatorium, apparatus has been installed whereby the natural radio-active waters of the Hot Springs may be inhaled, or used for special sprays,

* The figures given for niton are the weights of radium capable of forming the niton present in a million litres of water or gas.

in a finely atomised form. In suitable cases the gases from the springs, rich in valuable radium emanation, are applied in conjunction with the water.

In no other health resort is this special form of treatment carried out and the apparatus in this department of the Bathing Establishment has been specially designed for the application of the Bath Waters.

Experiments conducted over a considerable period have proved conclusively the value of this treatment, in conjunction with suitable baths and douches in rheumatic and gouty complaints, and in certain throat affections.

The Radium Inhalatorium contains apparatus for the following methods of treatment :—

Inhalation of the Bath Radio-active Mineral Water atomised by steam, air, or the valuable natural Niton gas.

Nasal Sprays of the Radio-active Water atomised by air or the natural Niton gas, and nasal douches of Mineral Water.

Ear Douches of Bath Radio-active Mineral Water may also be given.

Eye Sprays of the Bath Water, either pulverised by impinging against a polished metal plate or atomised by air or the natural Niton gas.

The discovery of the high degree of radio-activity in the Bath Springs indicates the direction in which still further developments may be expected in the application of the waters. It is the intention of the Corporation of Bath that no effort shall be spared to secure the fullest use of the valuable radium-emanation which recent scientific investigations have shown to be such an important factor in the therapeutics of the Hot Springs of Bath.

NOTES ON PATIENTS SENT TO BATH.

FURTHER NOTES ON RADIUM-THERAPY.

FURTHER NOTES ON RADIUM-THERAPY.